



## MEMORANDUM

To:	Joana Conklin, Darcy Buckley, Montgomery County DOT
From:	James A. Bunch, Senior Transportation Planner, SWAI
Subject:	US 29 Bus Rapid Transit Improvements, Montgomery County MD, TIGER VIII Grant Benefit Cost Analysis
Date:	April 28, 2016
CC:	Gary Erenrich, MCDOT, Paul Silberman: SWAI

## 1 Executive Summary

A benefit-cost analysis (BCA) was conducted for the US29 Bus Rapid Transit Improvements project for submission to the US DOT as a requirement of a discretionary grant application for the TIGER VIII program. The analysis was conducted in accordance with the benefit-cost methodology as recommended by the US DOT in the Federal Register (81 FR 9935)(18), and the 2016 Benefit-Cost Analysis Guidance for TIGER and Grant Applications (16) and the 2016 Tiger Benefit-Cost Analysis (BCA) 2016 TIGER and Fast Lane BCA Resource Guide (17). As recommended, the BCA was conducted for a period of more than 20 years starting when operations begin in 2020 and ending in 2040 (21 years). The BCA provides conservative estimates of both benefits and costs. Full life-cycle costs including replacement of assets at the end of their economic life, operations and maintenance of the system, and recovery of remaining useful life at the end of the analysis period were incorporated into the analysis. Sensitivity analyses using discount rates of 7% and 3% along with various assumptions on the methods and inputs for estimating the benefits measures (travel time savings, user cost savings, air quality, etc.) were also performed.

This memorandum provides additional detail on the assumptions, methods, and results discussed in the main grant submittal. All calculations and assumptions can also be found the accompanying Excel Workbook: E\_BCA-spreadsheet.xlsx.

**Table 1** provides the Project Benefit Summary Matrix summarizing the existing conditions, changes, impacts, affected populations, results, and location in the Excel Workbook.

### 1.1 Summary of Results

Table 2 provides a summary of the Benefit Analysis results. As shown, the project enhances the mobility and travel options within the US 29 corridor resulting in net benefits over the 21-year analysis period of \$1,106,324,787 in undiscounted 2015\$, and Net Present Value (NPV) of \$368,660,501 when a 7% discount rate is applied to future costs and benefits, or \$695,251,648 when a 3% discount rate is applied.

The \$66.57 million initial capital costs funded in part by the TIGER Grant increase to \$195.53 million in undiscounted 2015\$ (\$65.45 million NPV at 7% discount and \$99.65 million NPV at a 3% discount rate) over the 21-year life of the project primarily due to the replacement of the different components at the end of their economic life (vehicles at 12 years, bicycle stations and bikes at 10 years, passenger information displays at 5 years, and many other assets at 20 years). Note that the assets replaced at 20 years such as the Bus On Shoulder lane improvements are in service for only 1 year before the end of the analysis. All remaining value for these and other assets that have not reached the end of their economic value is subtracted in the Residual Capital Recovery calculations.



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**Table 1 Project Benefit Summary Matrix**

Current Status/Baseline & Problem to be Addressed	Change to Baseline/Alternative	Type of Impact	Population Affected By Impacts	Economic Benefit	Summary of Results (7% Discount, 20 years)	Page Reference in BCA (Spreadsheet)
<p>* Regional 2014 Constrained Long Range Plan assumptions and networks for 2014/2015 and 2040 prorated over 21 year analysis period (2020 to 2040).</p> <p>* Severe congestion exists north of the beltway on the US 29 corridor and is forecast to exacerbate in the future 2040 condition. This leads to extremely slow general purpose lane speeds in the peak period with transit vehicles caught in the general flow.</p> <p>* The study area has a strong transit market, including an average weekday daily Metrorail ridership of approximately 13,000 for Silver Spring Station and more than 15,000 boardings for the Metrobus Z line buses, Ride On buses, and MTA commuter buses.</p> <p>* Two regional activity centers, Silver Spring and White Oak/FDA, serve as an engine for activities and travel in the study area.</p> <p>* Strong employment growth in these two regional activity centers is forecasted for 2040, with a growth of almost 80% over current levels.</p> <p>* Intra-study-area trips represent a significant share of travel market for the study area, with approximately 40% of total trips in 2014 and are expected to increase by nearly 30% in 2040.</p> <p>* DC-bound commuting trips were a major out-flow of trips from the study area, with approximately 20,000 residents living in the study area and commuting to DC.</p> <p>* Another major DC-bound commuting flow of approximately 10,000 was from Howard County.</p>	<p>* US 29 BRT service from Burtonsville to Silver Spring</p> <p>* 14 miles with 12 station locations</p> <p>* Bus on Shoulder, Managed Lane and mixed flow ROW</p> <p>* Frequent (6 min. peak, 10 min. offpeak headways)</p> <p>* All Day service in both directions</p> <p>* 10 Bike Share Facilities</p> <p>* ADA pedestrian improvements</p> <p>* 17 covered bike racks</p> <p>* Improved station amenities (canopies, seating, passenger information, bike parking, etc.)</p> <p>* Outreach and Marketing</p> <p>* Transit Signal Priority</p> <p>* Specialty BRT Vehicles</p> <p>* Service revisions to the WMATA Express Lines that run duplicate service.</p> <p>* Implementation of feeder and circulator service to BRT stations.</p>	Change in system use (transit riders, road volumes, etc.)	Nobuild Transit Users that change route Nobuild Auto Users that change mode	Input into other impacts (below)	Travellers changing to transit from autos increases from 4,500 in 2020 to 6,100 in 2040 (37%). US 29 BRT Daily Boardings increase from 17,000 to 22,956 in 2040. Savings in Regional VMT is 29,800 in 2020 and 34,100 in 2040.	Demand Analysis & Travel time NPV
		Travel Time Savings	Existing transit users will divert to the new Rideon Plus service New transit users will divert to the BRT service	Monetized value of travel time savings	\$342,409,393	Travel Time NPV
		User Cost Savings	New transit riders that divert from using autos	Monetized value of User Cost Savings	\$43,796,093	User Cost NPV
		Air Quality reduction in emissions	New transit riders that divert from using autos All auto users	Monetized value of emission reductions	\$721,199	Air Quality NPV
		Reduced accidents on roadways due to lower VMT	Auto users on roadway after BRT implementation	Monetized value of accident costs	\$150,727,346	Safety NPV
		Good Repair savings	Reduction in parallel service provided by WMATA Metrobus Z Express Lines, and Ride On Service to White Oak	Savings in Ride On Operations and Maintenance Costs	Qualitative at this time	In main narrative
		Quality of Life due to lower congestion, increased bike use, healthier users	US 29 BRT Riders, and all residents, workers within corridor.		Qualitative at this time	In main narrative



**Table 2 Benefit-Cost Analysis Summary (2015\$)**

		Discount Rate		
		No Discount	7%	3%
<b>Benefits</b>				
<b>Good Repair</b>	Qualitative at this time			
<b>Economic</b>	<b>User Time Savings</b>	\$941,701,154	\$342,409,393	\$593,044,481
<b>Competitiveness</b>	<b>User Cost Savings</b>	\$116,613,017	\$43,796,093	\$74,495,028
<b>Quality of Life</b>	Qualitative at this time			
<b>Sustainability</b>	<b>Greenhouse Gas &amp; Emissions Cost Reductions</b>	\$1,738,364	\$721,199	\$1,161,357
<b>Safety</b>	<b>Accident Reduction</b>	\$387,036,916	\$150,727,346	\$251,480,268
	<b>Total Benefits</b>	\$ 1,447,089,450	\$537,654,030	\$920,181,135
<b>Costs</b>				
	<b>Capital Costs</b>	\$195,533,930	\$65,446,024	\$99,652,180
	<b>O&amp;M Costs</b>	\$145,230,733	\$103,547,506	\$125,277,306
	<b>Total Costs</b>	\$340,764,663	\$168,993,530	\$224,929,487
	<b>Benefits - Costs</b>	\$1,106,324,787	\$368,660,501	\$695,251,648

The operation and maintenance (O&M) costs of \$145,230,733 in undiscounted 2015\$ (\$103.55 million NPV at 7% discount and \$125.28 million NPV at a 3% discount rate) is significant and driven by the additional \$5.1 million annual cost to operate the US 29 BRT service. Other significant annual expenses include the maintenance of way at \$1 million per year, signing and marking at \$275 thousand, stations at \$200 thousand, fare equipment at \$127 thousand and bikeshare stations at \$125 thousand. The additional costs for the service operations are likely to be high since the concomitant savings from the service reductions of parallel service on the Express Z line routes in the corridor were not included, since they are operated by the Washington Metropolitan Area Transit Authority (WMATA) and could not be used to offset Montgomery County costs. While the specific reduction in parallel service has not been calculated at this time, benefits can be realized by assuming reductions in parallel route service of up to 10% per route since the ridership estimation and forecasts predicted a noticeable shift in existing riders to the new US 29 service.

After the remaining life at the end of the 21-year analysis period of all capital cost items is valued and subtracted, this results in a total cost over the 21 years of \$340,764,663 in undiscounted 2015\$ (\$169.0 million NPV at 7% discount and \$224.9 million NPV at a 3% discount rate).

The benefits that were quantified and valued for the cost-benefit analysis include those for Economic Competitiveness (travel time savings and user cost savings), Sustainability (reduction in emissions), and Safety (reduction in accidents). The benefits are the result of the improved transit travel times along the corridor, the institution of service in both directions throughout the day, and a reduction in wait times due to the more frequent service. On an average weekday, these lead to 4,460 new riders shifting from autos in 2020 and approximately 17,000 boardings throughout the day (the difference is due to existing riders changing to the new service). In 2040, this grows to 6,088 new riders and 23,000 boardings.

Consequently, the most significant benefits are shown to be from user travel time savings of \$941,701,154 in undiscounted 2015\$ (\$342.4 million NPV at 7% and \$593.0 million NPV at 3%). These benefits are conservative based upon the average time on the US 29 service and actual travel times. As explained in the full report, they would be higher if the travel-forecast door-to-door times accounting for the full trip, or the perceived times accounting for the additional inconvenience that travelers attribute to waiting or transferring, were used.

Travelers that switch from automobile to transit also can receive benefits due to the reduced out-of-pocket costs of their new transit trip versus driving a car and parking. These changes in user costs result in \$116,613,017 in undiscounted 2015\$ (\$43.8 million NPV at 7% and \$74.5 million NPV at 3%).

The air quality and safety benefits from reduced auto travel on the roads within the region and primarily along the corridor are also quantified for the cost-benefit analysis. The value of the air quality savings is \$1,738,364 in undiscounted 2015\$ (0.72 million NPV at 7% and 1.16 million at 3%). This will be higher increase due to service reductions in the parallel Z line service. Last are the safety benefits due to the reduction in auto travel. These are mostly due to injury only accidents and sum to \$387,036,916 in undiscounted 2015\$ (\$150.7 million NPV at 7% and \$251.5 million at 3%).

Overall this results in a positive net benefit – costs over the 21-year life of the project.

## 2 Methodologies and Assumptions

This section describes the basic methodologies and assumptions that were used to develop the inputs and carry out the Benefit-Cost Analysis. Throughout, general best practices in conducting economic assessments were used (see, 1, 13, 16, and 17) and will not be discussed here.

### 2.1 Travel Demand Analysis Model

This section summarizes the methods used to forecast the change in system usage due to the US 29 BRT Build alternative (transit ridership, transit boardings, auto vehicles miles traveled, etc. between the No-Build and the Build US 29 BRT Alternative, and how these change over time). The travel demand analysis model that was developed and calibrated for the Montgomery County US 29 BRT Corridor System Planning Study (see reference 6 for a full description) was chosen as a base model for the TIGER Grant analysis. It was based on the adopted regional travel forecasting model, MWCOC V 2.3.57 Regional Travel Demand Model with the 2014 CLRP networks and Round 8.3 Cooperative Land Use Forecasts (8, 10, 12). The regional model was last updated and adopted with the constrained long ranged plan networks and demographics in October 2014. It is a traditional trip-based, "four-step" travel model utilizing 4 feedback iterations with additional features including estimation of motorized and non-motorized trips, time-of-day modeling, and incorporation of detailed transit schedules from General Transit Feed Specification (GTFS) data. It was calibrated to the most recent transit ridership and other data in 2012 (9), and validated to the 2010 U.S. Census data in 2013 (11). (See <http://www.mwcog.org/transportation/activities/models/current.asp> for more). For the US 29 BRT Corridor System Planning Study (ongoing) carried out in coordination with Montgomery County, and the Maryland State Highway and Maryland Transit Administrations, additional Land Use reflecting the recently adopted White Oak Science Gateway Master Plan was incorporated in the land use forecasts along with additional network detail. This model was validated to 2014/2015 conditions and a No-Build 2040 land use and travel forecast scenario developed.

The US 29 BRT Corridor, study area, and Traffic Analysis Zones (TAZs) used are shown in Figure 1 (6). The 2014/2015 to 2040 Household and Employment Growth input into the models is shown in Figure 2 and Figure 3 (6).

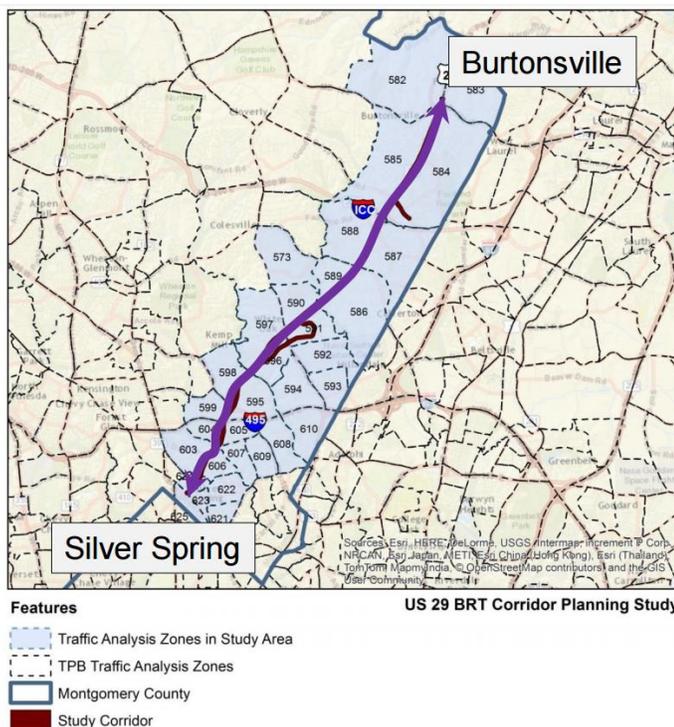


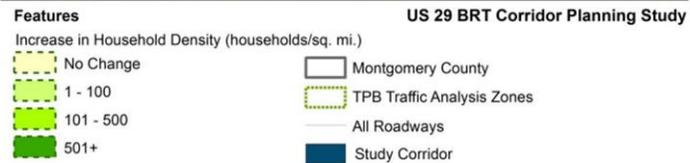
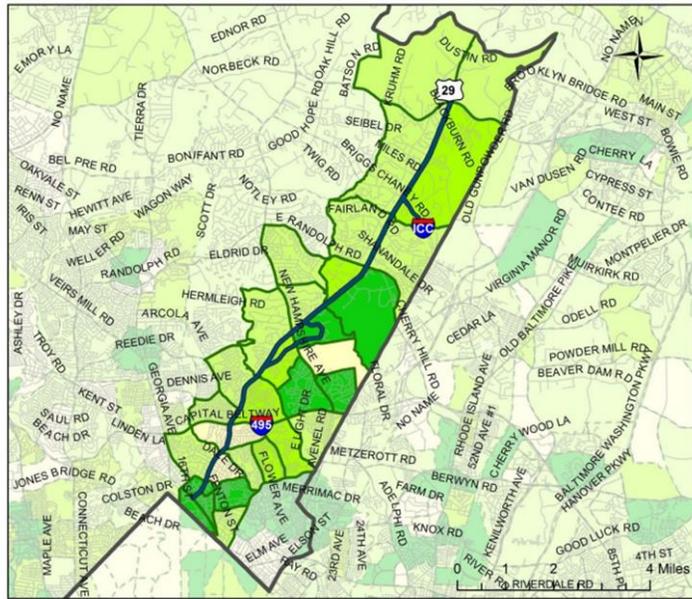
Figure 1 US 29 BRT Corridor and Traffic Analysis Zones (TAZs)

**Household Growth 2014/2015 to 2040**

- 52,100 Households in 2014
- 61,000 Households in 2040  
 (17% increase)

Where do these numbers come from?  
 MWCOG Round 8.3, with update from Montgomery County, which provides the future forecasts of both households and employment through the Parks & Planning office.

(<http://www.montgomeryplanning.org/>)



Source: Cambridge Systematics, based on MWCOG Round 8.3 and Montgomery County



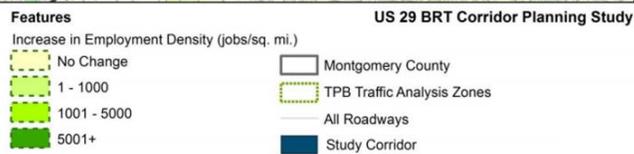
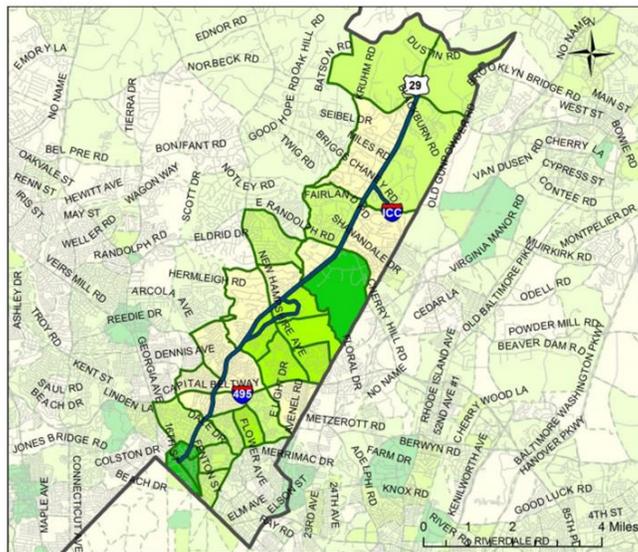
Figure 2 Household Growth 2014/2015 to 2040

**Employment Growth 2014/2015 to 2040**

- 2014 Employment 67,400
- 2040 Employment 120,000  
 (78% increase)

Where do these numbers come from?  
 MWCOG Round 8.3, with update from Montgomery County, which provides the future forecasts of both households and employment through the Parks & Planning office.

(<http://www.montgomeryplanning.org/>)



Source: Cambridge Systematics, based on MWCOG Round 8.3 and Montgomery County



Figure 3 2014/2015 Employment Growth

For this analysis a pivot point approach was chosen for carrying out the forecasts. In this approach, the trip generation and trip distribution (person trips) from the baseline regional model runs remain fixed and the last iteration skims (highway and transit), mode choice, and assignments (highway and transit) are rerun with the new transit inputs. This approach was warranted because it is unlikely that a single new transit line should impact regional trip productions and overall travel patterns, and using the person trip distribution from a no-build alternative is recommended by the FTA for transit alternative analyses. The results of the travel demand analysis are shown in Table 3 (see the "Travel Demand" tab in the accompanying Excel Workbook). The change was distributed by year from 2015 to 2040 using a straight line allocation (see the Travel NVP TAB rows 56-83).

**Table 3 Summary of Travel Demand Results**

	Year		Regional Linked Transit Trips	US 29 BRT Brdings	Veh Trips	VMT	VMT/Trip	Ave Spd	Auto		
									VHT	Occ	APHT
Model	2015	No Build	1159626		16681291	165465035	9.92	32.28	5126358	1.41	7228165
		US 29	1163679	15530	16677965	165436241	9.92	32.29	5123837	1.41	7224610
		Change	4053		-3326	-28794			-2521		-3555
Model	2040	No Build	1583928		20452069	207777313	10.16	27.59	7531933	1.43	10770664
		US 29	1590016	22956	20447671	207743184	10.16	27.60	7527600	1.43	10764468
		Change	6088		-4398	-34129			-4333		-6196
% change	2015-2040	Nobuild	36.59%		22.60%	25.57%	0.02	-0.15	0.47		0.49
% change	2015-2040	BRT	36.64%	47.82%	22.60%	25.57%	0.02	-0.15	0.47		0.49

Source: US 29 BRT Study Model (MWCOG V 2.3.57 Regional Travel Demand Model 2014 CLRPP and Round 8.3 Cooperative Forecasts with White Oak Science Gateway Land Use) pivot analyses.

Trip Generation and Trip Distribution Fixed

Final iteration

## 2.2 Alternatives (No-Build and US 29 BRT)

Key to any economic analysis is the careful definition of the No-Build and US 29 BRT Build service to capture all of the potential impacts and costs that may be caused by a project's implementation. If too narrow a corridor or system is defined then impacts or costs may be overlooked. Consequently, the following was assumed for the No-Build and Build (US29 BRT) service:

- No-Build Alternatives (2014/2015 and 2040):
  - MWCOG 2014 CLRPP system plus US 29 BRT Corridor current and 2040 No-Build network changes
  - Regional Round 8.3 cooperative land use forecasts with White Oak Science Gateway Master Plan growth in the White Oak Area.
  - Current transit service for 2014/2015 and 2040. All inputs and outputs prorated for the analysis of the years of operation (2020-2040).
  - Current Transit Service schedule run times (degraded in model for future years by forecast congestion factor) (10).
- Build US29 BRT Alternative.
  - The 2014/2015 and 2040 No-Build transit service as background service with the following changes (see reference 1 for service configuration details).
  - 6 minute peak and 10 minute off peak headways
  - Station Dwell at BRT Stops of 30 seconds (reflects off board fare payment, multi-door boarding, etc.)
  - Transit Signal Priority on all Vehicles with TSP at 15 signals along corridor. Travel time savings due to TSP in the peak are assumed to be 7.5% and for the off peak 5 seconds per intersection) (5).

- The following US 29 BRT Stations/Stops as shown in Figure 4:

Pattern 1	Pattern 2
Burtonsville PNR	--
--	Castle Terrace
--	Castle Ridge
--	Briggs Chaney PNR
Tech Rd	Tech Rd
Stewart Lane	--
White Oak TC	--
OakLeaf Dr.	--
Burnt Mills Ave	Burnt Mills Ave
University Blvd	University Blvd
Fenton St	Fenton St
Silver Spring TC	Silver Spring TC

- Modifications to current service as follows:
  - Remove WMATA Z11 and Z13 Express service to Briggs Chaney Park and Ride
  - Remove WMATA Z9/Z29 Express service to Burtonsville Park and Ride
  - Extend WMATA Z8 local service to cover area previously served by the Z11
  - Extend the WMATA Z6 local peak service to cover area previously served by the Z9/Z29
  - Create new feeder service from South Laurel to Burtonsville (previously Z9/Z29)
  - Terminate Ride-On 21 and 22 at the White Oak Transit Center
  - Extend the WMATA Express Service from FDA to the White Oak Transit Center
  - Add a White Oak Science Center circulator/Shuttle to and from the Tech Road BRT Station.
- Incorporate BRT ROW Road Changes to reflect recommended priority treatments shown in Figure 5 US 29 BRT ROW Treatments:
  - Bus on Shoulder = 20 mph above parallel Roadway. In 2015 ~ 45 mph
  - Managed Lanes = Free flow of general purpose lanes. In 2015 varies from 20 to 30 mph
  - Mixed Use = Congested speeds. In 2015 varies from 15 to 25 mph
  - Reverse direction in mixed flow

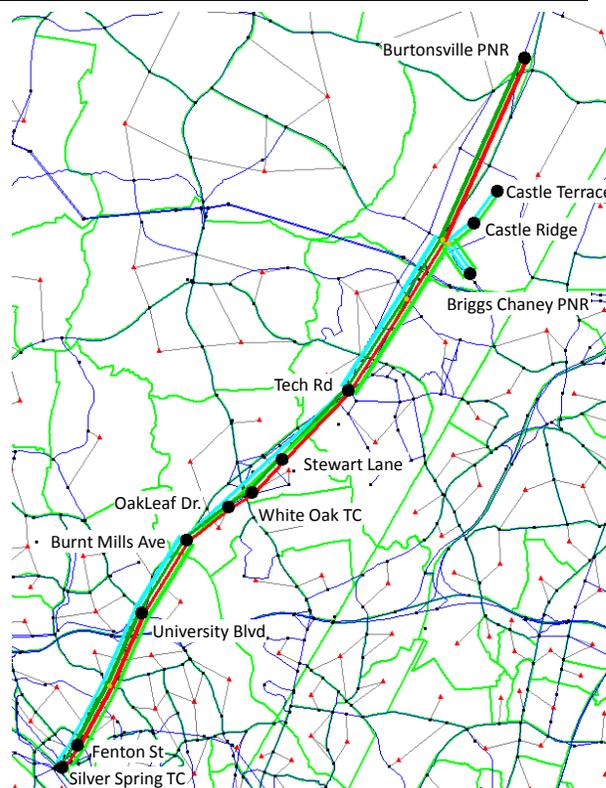


Figure 4 US 29 BRT Build Coded Routes

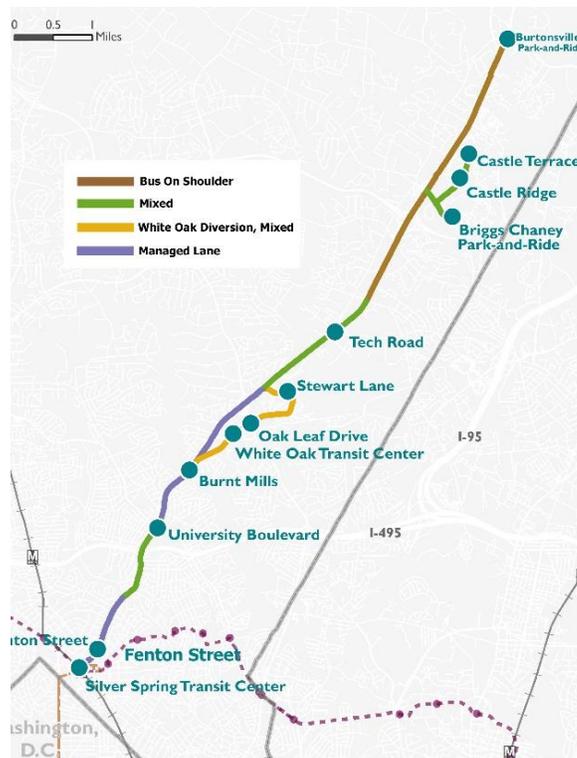


Figure 5 US 29 BRT ROW Treatments

## **2.3 General Assumptions**

The general assumptions used throughout the Benefit-Cost Analysis are as follows:

- All input dollar values are expressed in 2015\$ constant dollars.
- The analysis period begins in 2017 with a 3 year start up (2017, 2018, 2019), and 21 years of operation (2020 – 2040).
- No construction or startup costs or significant user impacts are anticipated.
- A constant 7 percent real discount rate is used throughout the analysis. Sensitivity analyses are also provided for both 3 and 0 percent real discount rates.
- Standard formulas for discounting and converting life cycles of costs and benefits to Net Present Value are used throughout (17, 13)
- Average Weekday Annualization factor of 290. This is in between the current ratio of average weekday to annual boardings for Montgomery County Ride On of 302, and a focused peak period service provided only on weekdays (~290). New Starts Projects for the FTA often use values ranging from 280 to 300, with special justification requested for values approaching 300.

## **3 Benefits (Impacts)**

The analyses and their major assumptions that were used to estimate the quantifiable benefits (impacts) from the US 29 BRT Service are described in this section. This includes User Time Savings, User Cost Savings, Greenhouse Gas and Emissions Cost Reductions, and Accident Cost Savings. All are documented in the accompanying Excel Workbook.

### **3.1 User Time Savings**

The User Time Savings benefits are due to the improved transit travel times along the corridor (from mixed flow service along US 29 to a mixture of Bus on Shoulder at 20 mph above the parallel general traffic lanes, managed lane service at free flow speeds, and small segments of mixed flow), institution of 2 way service throughout the day, and a reduction in wait times caused by BRT headways of 6 minutes in the peak and 10 minutes in the off-peak periods. On an average weekday, these lead to 4,460 new riders shifting from autos in 2020 and approximately 17,000 boardings throughout the day (the difference is due to existing riders changing to the new service). In 2040, this grows to 6,088 new riders and 23,000 boardings.

Time savings are calculated first by estimating difference in Auto Passenger Hours Traveled from the Vehicle Hours Traveled from the highway assignments between the No-Build and US 29 BRT Build alternatives. Second, hours saved by those using the US 29 BRT Service are estimated from the change in wait time plus the time saved due to the faster speeds for those boarding the system (see the Demand Analysis and Travel Time NVP Tabs). These time savings are then multiplied by the average \$13.45 per hour value of time in 2015 grown by 1.2 % a year for urban areas as recommended in the 2016 TIGER CBA Resource Guide (17).

The User Time Saving Calculations are calculated in the Travel Time NVP tab and shown in Table 4. The Net Present Value (NPV) of the savings across the 21 year analysis period is \$941,701,154 in undiscounted 2015\$ (\$342.4 million NPV at 7% and \$593.0 million NPV at 3%). These benefits are conservative based upon the average time on the US 29 BRT service and actual travel times. They would be higher if the travel-forecast door-to-door times accounting for the full trip, or the perceived times accounting for the additional inconvenience that travelers attribute to waiting or transferring, were used. The time savings from these alternative methods are also shown in the Travel Time NVP tab.

**Table 4 User Value of Time NPV**

	Year	Transit Time Savings (Hours)	Auto Time Savings (Hours)	Ave. Wk. day Time Savings (Hrs)	Annualization Factor	Annual Time Savings (Hrs)	VOT (All Trips) (2015\$/hr)	Total 2015 \$	NPV 7%	NPV 3%
	2015						\$13.45			
	2016						\$13.61			
Startup	2017						\$13.77			
	2018						\$13.94			
	2019						\$14.11			
1	2020	3482	4083	7564	290	2193695	\$14.28	\$ 31,318,506	\$ 22,329,662	\$ 27,015,618
2	2021	3570	4189	7758	290	2249924	\$14.45	\$ 32,506,723	\$ 21,660,602	\$ 27,223,869
3	2022	3658	4294	7952	290	2306153	\$14.62	\$ 33,718,949	\$ 20,998,467	\$ 27,416,591
4	2023	3746	4400	8146	290	2362382	\$14.80	\$ 34,955,586	\$ 20,344,470	\$ 27,594,263
5	2024	3834	4506	8340	290	2418612	\$14.97	\$ 36,217,048	\$ 19,699,674	\$ 27,757,351
6	2025	3923	4611	8534	290	2474841	\$15.15	\$ 37,503,751	\$ 19,065,005	\$ 27,906,313
7	2026	4011	4717	8728	290	2531070	\$15.34	\$ 38,816,119	\$ 18,441,259	\$ 28,041,590
8	2027	4099	4823	8922	290	2587299	\$15.52	\$ 40,154,584	\$ 17,829,116	\$ 28,163,617
9	2028	4187	4928	9116	290	2643529	\$15.71	\$ 41,519,582	\$ 17,229,151	\$ 28,272,815
10	2029	4276	5034	9310	290	2699758	\$15.89	\$ 42,911,559	\$ 16,641,842	\$ 28,369,595
11	2030	4364	5140	9503	290	2755987	\$16.09	\$ 44,330,963	\$ 16,067,581	\$ 28,454,358
12	2031	4452	5245	9697	290	2812216	\$16.28	\$ 45,778,255	\$ 15,506,679	\$ 28,527,495
13	2032	4540	5351	9891	290	2868446	\$16.47	\$ 47,253,897	\$ 14,959,374	\$ 28,589,385
14	2033	4629	5457	10085	290	2924675	\$16.67	\$ 48,758,363	\$ 14,425,840	\$ 28,640,399
15	2034	4717	5562	10279	290	2980904	\$16.87	\$ 50,292,131	\$ 13,906,193	\$ 28,680,900
16	2035	4805	5668	10473	290	3037133	\$17.07	\$ 51,855,689	\$ 13,400,495	\$ 28,711,238
17	2036	4893	5774	10667	290	3093363	\$17.28	\$ 53,449,530	\$ 12,908,761	\$ 28,731,756
18	2037	4981	5879	10861	290	3149592	\$17.49	\$ 55,074,156	\$ 12,430,962	\$ 28,742,789
19	2038	5070	5985	11055	290	3205821	\$17.70	\$ 56,730,077	\$ 11,967,033	\$ 28,744,662
20	2039	5158	6091	11248	290	3262050	\$17.91	\$ 58,417,808	\$ 11,516,873	\$ 28,737,691
21	2040	5246	6196	11442	290	3318280	\$18.12	\$ 60,137,877	\$ 11,080,354	\$ 28,722,185
							<b>Total</b>	\$ 941,701,154	\$ 342,409,393	\$ 593,044,481

### 3.2 User Cost Savings

Travelers that switch from automobile to transit also can receive benefits due to the reduced out-of-pocket costs of their new transit trip versus driving a car and parking. These benefits are estimated from the new transit trips that use the US 29 BRT Service. This is provided from the change in Vehicle Miles Travelled from the travel demand model. The change in VMT is multiplied by the 2015 total cost of driving a car of \$0.54 per mile provided by the Internal Revenue Service (14). The potential cost of parking is also added assuming an average \$5.00 in 2015\$ and 25% pay for parking currently and 50% pay for parking in 2040. The increased percentage is due to the additional development and densification in the activity centers along the corridor (Silver Spring, White Oak) and the implementation of travel demand management strategies to meet reduction in drive alone vehicle trips. An average US 29 BRT fare is also incorporated.

The User Cost Savings are calculated in the User Cost NPV tab and also shown in Table 5. These changes in user costs result in \$116,613,017 in undiscounted 2015\$ (\$43.8 million NPV at 7% and \$74.5 million NPV at 3%).

**Table 5 User Cost Savings NPV**

	Year	Change in Transit Person Trips	Avg weekday change in Auto VMT	Avg weekday change in mile costs	Avg Weekday change in Parking Costs	Avg Weekday Fares Paid (\$1.75/Trip)	Avg Weekday Cost Savings	Annual Auto Cost Savings	Total 2015 \$	NPV 7%	NPV 3%
	2015										
	2016										
Startup	2017										
	2018										
	2019										
1	2020	4460	29861	\$16,125	\$7,097	\$7,805	\$15,417	\$4,470,913	\$ 4,470,913	\$ 3,187,699	\$ 3,856,648
2	2021	4541	30074	\$16,240	\$7,503	\$7,947	\$15,796	\$4,580,804	\$ 4,580,804	\$ 3,052,383	\$ 3,836,351
3	2022	4623	30288	\$16,355	\$7,909	\$8,090	\$16,175	\$4,690,695	\$ 4,690,695	\$ 2,921,129	\$ 3,813,965
4	2023	4704	30501	\$16,471	\$8,315	\$8,232	\$16,554	\$4,800,587	\$ 4,800,587	\$ 2,793,985	\$ 3,789,628
5	2024	4786	30715	\$16,586	\$8,722	\$8,375	\$16,933	\$4,910,478	\$ 4,910,478	\$ 2,670,975	\$ 3,763,673
6	2025	4867	30928	\$16,701	\$9,128	\$8,517	\$17,312	\$5,020,370	\$ 5,020,370	\$ 2,552,101	\$ 3,735,627
7	2026	4948	31141	\$16,816	\$9,534	\$8,660	\$17,691	\$5,130,261	\$ 5,130,261	\$ 2,437,350	\$ 3,706,210
8	2027	5030	31355	\$16,932	\$9,940	\$8,802	\$18,069	\$5,240,153	\$ 5,240,153	\$ 2,326,690	\$ 3,675,338
9	2028	5111	31568	\$17,047	\$10,346	\$8,945	\$18,448	\$5,350,044	\$ 5,350,044	\$ 2,220,078	\$ 3,643,120
10	2029	5193	31782	\$17,162	\$10,752	\$9,087	\$18,827	\$5,459,936	\$ 5,459,936	\$ 2,117,457	\$ 3,609,661
11	2030	5274	31995	\$17,277	\$11,159	\$9,229	\$19,206	\$5,569,827	\$ 5,569,827	\$ 2,018,762	\$ 3,575,060
12	2031	5355	32208	\$17,393	\$11,565	\$9,372	\$19,585	\$5,679,718	\$ 5,679,718	\$ 1,923,917	\$ 3,539,413
13	2032	5437	32422	\$17,508	\$11,971	\$9,514	\$19,964	\$5,789,610	\$ 5,789,610	\$ 1,832,842	\$ 3,502,809
14	2033	5518	32635	\$17,623	\$12,377	\$9,657	\$20,343	\$5,899,501	\$ 5,899,501	\$ 1,745,450	\$ 3,465,335
15	2034	5600	32849	\$17,738	\$12,783	\$9,799	\$20,722	\$6,009,393	\$ 6,009,393	\$ 1,661,647	\$ 3,427,073
16	2035	5681	33062	\$17,853	\$13,189	\$9,942	\$21,101	\$6,119,284	\$ 6,119,284	\$ 1,581,339	\$ 3,388,099
17	2036	5762	33275	\$17,969	\$13,595	\$10,084	\$21,480	\$6,229,176	\$ 6,229,176	\$ 1,504,427	\$ 3,348,489
18	2037	5844	33489	\$18,084	\$14,002	\$10,227	\$21,859	\$6,339,067	\$ 6,339,067	\$ 1,430,811	\$ 3,308,312
19	2038	5925	33702	\$18,199	\$14,408	\$10,369	\$22,238	\$6,448,959	\$ 6,448,959	\$ 1,360,388	\$ 3,267,634
20	2039	6007	33916	\$18,314	\$14,814	\$10,512	\$22,617	\$6,558,850	\$ 6,558,850	\$ 1,293,055	\$ 3,226,520
21	2040	6088	34129	\$18,430	\$14,002	\$10,654	\$21,777	\$6,315,391	\$ 6,315,391	\$ 1,163,606	\$ 3,016,266
				Total Auto Cost Per Mile =		\$0.540		<b>Total</b>	\$ 116,613,017	\$ 43,796,093	\$ 74,495,028
				Annualization Factor =		.290					
				Avg Fare =		\$1.75					

### 3.3 Greenhouse Gas & Emissions Cost Reductions

The Greenhouse Gas & Emissions Cost Reductions are estimated from the change in auto vehicle miles traveled from the No-Build and US 29 BRT Build alternative highway assignments, multiplied by the emissions rates recommended by the Federal Transit Administration for New Starts Analyses (3) and the valuation of emissions savings from the 2016 TIGER CBA Resource Guide (17).

The Greenhouse Gas & Emissions Cost Reductions are calculated in the Air Quality NPV tab and also shown in Table 6 Air Quality NPV. The value of the air quality savings is \$1,738,364 in undiscounted 2015\$ (\$.72 million NPV at 7% and \$1.16 million at 3%).

**Table 6 Air Quality NPV**

												Current Year = 2015			
	Year	Avg Weekday Savings in Auto VMT	Annual Savings in Auto VMT	Change in CO (Metric Tons)	Change in NOx (Metric Tons)	Change in VOC (Metric Tons)	Change in PM2.5 (Metric Tons)	Value of CO 2015\$	Value of NOx 2015\$	Value of VOC 2015\$	Value of PM2.5 2015\$	Total Value Emissions (2015\$)	Total 2015 \$	NPV 7%	NPV 3%
	2015														
	2016														
Startup	2017														
	2018														
	2019														
1	2020	29861	8659690	133.94808	6.65064	4.52036	0.08660	\$ 6,162	\$ 53,272	\$ 9185.36782	\$ 31,730	\$ 100,349	\$ 100,349	\$ 71,547	\$ 86,562
2	2021	30074	8721576	132.63424	6.45048	4.41661	0.08722	\$ 6,234	\$ 51,668	\$ 8974.54357	\$ 31,957	\$ 98,834	\$ 98,834	\$ 65,857	\$ 82,772
3	2022	30288	8783462	131.28816	6.24680	4.31092	0.08783	\$ 6,171	\$ 50,037	\$ 8759.79584	\$ 32,184	\$ 97,151	\$ 97,151	\$ 60,501	\$ 78,993
4	2023	30501	8845348	129.90986	6.03960	4.20331	0.08845	\$ 6,236	\$ 48,377	\$ 8541.12464	\$ 32,411	\$ 95,565	\$ 95,565	\$ 55,620	\$ 75,440
5	2024	30715	8907234	128.49932	5.82889	4.09376	0.08907	\$ 6,485	\$ 46,689	\$ 8318.52996	\$ 32,637	\$ 94,070	\$ 94,070	\$ 51,168	\$ 72,097
6	2025	30928	8969120	127.05655	5.61647	3.98229	0.08969	\$ 6,480	\$ 44,973	\$ 8092.01182	\$ 32,864	\$ 92,410	\$ 92,410	\$ 46,976	\$ 68,761
7	2026	31141	9031006	125.58156	5.39693	3.86888	0.09031	\$ 6,530	\$ 43,229	\$ 7861.57020	\$ 33,091	\$ 90,712	\$ 90,712	\$ 43,097	\$ 65,532
8	2027	31355	9092892	124.07433	5.17567	3.75355	0.09093	\$ 6,576	\$ 41,457	\$ 7627.20510	\$ 33,318	\$ 88,978	\$ 88,978	\$ 39,507	\$ 62,407
9	2028	31568	9154778	122.53487	4.95090	3.63628	0.09155	\$ 6,617	\$ 39,657	\$ 7388.91653	\$ 33,544	\$ 87,207	\$ 87,207	\$ 36,188	\$ 59,384
10	2029	31782	9216664	120.96319	4.72262	3.51708	0.09217	\$ 6,653	\$ 37,828	\$ 7146.70449	\$ 33,771	\$ 85,399	\$ 85,399	\$ 33,119	\$ 56,459
11	2030	31995	9278550	119.35927	4.49082	3.39595	0.09279	\$ 6,565	\$ 35,971	\$ 6900.56898	\$ 33,998	\$ 83,435	\$ 83,435	\$ 30,241	\$ 53,554
12	2031	32208	9340436	117.72312	4.25550	3.27289	0.09340	\$ 6,592	\$ 34,087	\$ 6650.50999	\$ 34,225	\$ 81,554	\$ 81,554	\$ 27,625	\$ 50,822
13	2032	32422	9402322	116.05474	4.01667	3.14790	0.09402	\$ 6,731	\$ 32,174	\$ 6396.52753	\$ 34,451	\$ 79,753	\$ 79,753	\$ 25,248	\$ 48,252
14	2033	32635	9464208	114.35413	3.77433	3.02098	0.09464	\$ 6,747	\$ 30,232	\$ 6138.62159	\$ 34,678	\$ 77,796	\$ 77,796	\$ 23,017	\$ 45,697
15	2034	32849	9526094	112.62129	3.52847	2.89212	0.09526	\$ 6,757	\$ 28,263	\$ 5876.79219	\$ 34,905	\$ 75,802	\$ 75,802	\$ 20,960	\$ 43,229
16	2035	33062	9587980	110.85622	3.27909	2.76134	0.09588	\$ 6,762	\$ 26,266	\$ 5611.03930	\$ 35,132	\$ 73,771	\$ 73,771	\$ 19,064	\$ 40,845
17	2036	33275	9649866	109.05893	3.02620	2.62862	0.09650	\$ 6,762	\$ 24,240	\$ 5341.36295	\$ 35,358	\$ 71,701	\$ 71,701	\$ 17,317	\$ 38,543
18	2037	33489	9711752	107.22940	2.76979	2.49398	0.09712	\$ 6,755	\$ 22,186	\$ 5067.76312	\$ 35,585	\$ 69,595	\$ 69,595	\$ 15,708	\$ 36,321
19	2038	33702	9773638	105.36764	2.50987	2.35740	0.09774	\$ 6,744	\$ 20,104	\$ 4790.23982	\$ 35,812	\$ 67,450	\$ 67,450	\$ 14,228	\$ 34,176
20	2039	33916	9835524	103.47365	2.24643	2.21889	0.09836	\$ 6,726	\$ 17,994	\$ 4508.79304	\$ 36,039	\$ 65,267	\$ 65,267	\$ 12,867	\$ 32,107
21	2040	33489	9711752	99.64258	1.94235	2.03947	0.09712	\$ 6,277	\$ 15,558	\$ 4144.19881	\$ 35,585	\$ 61,565	\$ 61,565	\$ 11,343	\$ 29,404
												<b>Total</b>	\$ 1,738,364	\$ 721,199	\$ 1,161,357

Note, that the air quality benefits assume that the US29 BRT service will use Clean Diesel or CNG vehicles with a zero net impact in emissions when the current service that is being reduced is taken into account.

### 3.4 Accident Reductions

The savings due to accident reductions are estimated based on the savings in auto vehicle mile traveled from No-Build and US 29 BRT Build alternative highway assignments multiplied by the Montgomery County accident rates obtained from the Maryland State Highway Administration (**Error! Reference source not found.**). These produce estimated changes in Property Damage Only (PDO), Injury, and Fatal crashes which are then multiplied by the recommended values described in the 2016 TIGER BCA Resource Guide (17).

The Accident Reduction cost savings are calculated in the Safety NPV tab and shown in Table 7. These are mostly due to injury only accidents and sum to \$387,036,916 in undiscounted 2015\$ (\$150.7 million NPV at 7% and \$251.5 million at 3%).

**Table 7 Accident Reduction NPV**

													Current Year = 2015		
	Year	Avg Weekday Savings in VMT	Annual Savings in VMT	Annual Change PDO Crashes	Annual Change Inj Crashes	Annual Change Fatal Crashes	Value PDO Crashes (2015\$)	Value Inj Crashes (2014\$)	Value Fatal Crashes (2015\$)	Total Value Crashes (2015\$)	Total 2015 \$	NPV 7%	NPV 3%		
	2015														
	2016														
Startup	2017														
	2018														
	2019														
1	2020	29861	8659690	6.86756	4.02641	0.03468	\$ 28,830	\$ 16,839,322	\$ 332,913	\$ 17,201,065	\$ 17,201,065	\$ 12,264,121	\$ 14,837,789		
2	2021	30074	8721576	6.91664	4.05518	0.03493	\$ 29,036	\$ 16,959,663	\$ 335,292	\$ 17,323,991	\$ 17,323,991	\$ 11,543,707	\$ 14,508,570		
3	2022	30288	8783462	6.96572	4.08396	0.03517	\$ 29,242	\$ 17,080,005	\$ 337,671	\$ 17,446,918	\$ 17,446,918	\$ 10,865,063	\$ 14,185,941		
4	2023	30501	8845348	7.01480	4.11273	0.03542	\$ 29,448	\$ 17,200,346	\$ 340,050	\$ 17,569,844	\$ 17,569,844	\$ 10,225,809	\$ 13,869,797		
5	2024	30715	8907234	7.06387	4.14151	0.03567	\$ 29,654	\$ 17,320,687	\$ 342,429	\$ 17,692,771	\$ 17,692,771	\$ 9,623,695	\$ 13,560,035		
6	2025	30928	8969120	7.11295	4.17028	0.03592	\$ 29,860	\$ 17,441,029	\$ 344,808	\$ 17,815,697	\$ 17,815,697	\$ 9,056,597	\$ 13,256,552		
7	2026	31141	9031006	7.16203	4.19906	0.03617	\$ 30,066	\$ 17,561,370	\$ 347,187	\$ 17,938,623	\$ 17,938,623	\$ 8,522,511	\$ 12,959,243		
8	2027	31355	9092892	7.21111	4.22783	0.03641	\$ 30,272	\$ 17,681,711	\$ 349,567	\$ 18,061,550	\$ 18,061,550	\$ 8,019,544	\$ 12,668,008		
9	2028	31568	9154778	7.26019	4.25661	0.03666	\$ 30,478	\$ 17,802,052	\$ 351,946	\$ 18,184,476	\$ 18,184,476	\$ 7,545,911	\$ 12,382,744		
10	2029	31782	9216664	7.30927	4.28538	0.03691	\$ 30,684	\$ 17,922,394	\$ 354,325	\$ 18,307,403	\$ 18,307,403	\$ 7,099,926	\$ 12,103,350		
11	2030	31995	9278550	7.35835	4.31415	0.03716	\$ 30,890	\$ 18,042,735	\$ 356,704	\$ 18,430,329	\$ 18,430,329	\$ 6,680,000	\$ 11,829,727		
12	2031	32208	9340436	7.40743	4.34293	0.03740	\$ 31,096	\$ 18,163,076	\$ 359,083	\$ 18,553,256	\$ 18,553,256	\$ 6,284,630	\$ 11,561,776		
13	2032	32422	9402322	7.45650	4.37170	0.03765	\$ 31,302	\$ 18,283,418	\$ 361,462	\$ 18,676,182	\$ 18,676,182	\$ 5,912,401	\$ 11,299,397		
14	2033	32635	9464208	7.50558	4.40048	0.03790	\$ 31,508	\$ 18,403,759	\$ 363,841	\$ 18,799,109	\$ 18,799,109	\$ 5,561,978	\$ 11,042,495		
15	2034	32849	9526094	7.55466	4.42925	0.03815	\$ 31,714	\$ 18,524,100	\$ 366,221	\$ 18,922,035	\$ 18,922,035	\$ 5,232,100	\$ 10,790,972		
16	2035	33062	9587980	7.60374	4.45803	0.03840	\$ 31,920	\$ 18,644,441	\$ 368,600	\$ 19,044,962	\$ 19,044,962	\$ 4,921,580	\$ 10,544,734		
17	2036	33275	9649866	7.65282	4.48680	0.03864	\$ 32,127	\$ 18,764,783	\$ 370,979	\$ 19,167,888	\$ 19,167,888	\$ 4,629,296	\$ 10,303,684		
18	2037	33489	9711752	7.70190	4.51558	0.03889	\$ 32,333	\$ 18,885,124	\$ 373,358	\$ 19,290,815	\$ 19,290,815	\$ 4,354,191	\$ 10,067,731		
19	2038	33702	9773638	7.75098	4.54435	0.03914	\$ 32,539	\$ 19,005,465	\$ 375,737	\$ 19,413,741	\$ 19,413,741	\$ 4,095,268	\$ 9,836,782		
20	2039	33916	9835524	7.80005	4.57312	0.03939	\$ 32,745	\$ 19,125,807	\$ 378,116	\$ 19,536,668	\$ 19,536,668	\$ 3,851,588	\$ 9,610,746		
21	2037	34129	9897410	7.84913	4.60190	0.03963	\$ 32,951	\$ 19,246,148	\$ 380,495	\$ 19,659,594	\$ 19,659,594	\$ 4,437,429	\$ 10,260,195		
				Annualization Factor =	290					<b>Total</b>	\$ 387,036,916	\$ 150,727,346	\$ 251,480,268		

## 4 Costs

The cost items used for the Benefit-Cost Analysis are provided in the Cost Items tab and shown in Table 8. All items were provided based upon current experience by the Montgomery County Department of Transportation and Ride On. Note, that the costs assume that the US 29 BRT service will be implemented with reductions in the Z 29 express current transit service routes that provide parallel service and some Ride On service into White Oak. Since these services are provided by WMATA and it would be difficult to offset the savings to Montgomery County the savings were not included in the analysis. This leads to a conservative overall benefits-costs assessment.

The economic life of each capital asset is also an important input for carrying out full life cycle costing in a BCA. The values shown in Table 8 are those recommended by the Federal Transit Administration for transit assets (1) and for technology components from the USDOT ITS Cost database (4).

**Table 8 Cost Items**

Element	Starting Year	Economic Life <sup>a</sup>	Units	Unit Cost (2015\$)		Total Cost (2015\$)	
				Capital	Annual O&M	Capital	Annual O&M
<b>Planning/Design</b>							
Planning, Engineering, Design	2017	-	1	\$ 6,500,000		\$ 6,500,000	
<b>Vehicles</b>							
Bus - BRT Articulated (including CAD/AVL and Fare Collec	2020	12	13	\$ 1,000,000	See US29 BRT Service	\$ 13,000,000	See US29 BRT Service
TSP OnBoard Purchase & Install (w Engineering)	2020	10	12	\$ 20,000	\$ 417	\$ 240,000	\$ 5,000
<b>Stops/Stations</b>							
Concreate Pad	2020	20	16	\$ 45,000	\$ 2,250	\$ 720,000	\$ 36,000
Canopy/Shelter Add/Upgrade	2020	30	16	\$ 248,624	\$ 12,431	\$ 3,977,984	\$ 198,899
RTPI Signs	2020	5	17	\$ 21,300	\$ 1,000	\$ 362,100	\$ 17,000
Right-of-way and Easements	2020	125	16	\$ 50,000		\$ 800,000	\$ -
Off Board Fare Collection Equipment	2020	25	16	\$ 106,500	\$ 7,988	\$ 1,704,000	\$ 127,800
Benches	2020	30	16	\$ 6,800		\$ 108,800	\$ -
Trash Recepticles	2020	30	16	\$ 3,200		\$ 51,200	\$ -
Bike Racks	2020	30	16	\$ 1,600	\$ 50	\$ 25,600	\$ 800
Bicycle Parking (Covered)	2020	30	13	\$ 15,000	\$ 500	\$ 195,000	\$ 6,500
Bicycle Share Station (Bikes & Docks)	2020	10	10	\$ 80,000	\$ 12,500	\$ 800,000	\$ 125,000
ADA Sidewalk upgrades (feet total)	2020	25	6500	\$ 200	\$ -	\$ 1,300,000	\$ -
<b>Roadside/Right of Way</b>							
TSP Field Hardware & Install (w Engineering)	2020	10	15	\$ 35,000	\$ 1,200	\$ 525,000	\$ 18,000
Signing and Marking of BAT and HOV Lanes (lane miles)	2020	20	22	\$ 250,000	\$ 12,500	\$ 5,500,000	\$ 275,000
Signal changes for BAT Lane	2020	20	15	\$ 500,000	\$ 250	\$ 7,500,000	\$ 3,750
Bus on Shoulder Burtonsville to Tech Road (lane miles)	2020	20	10	\$ 2,000,000	\$ 100,000	\$ 20,000,000	\$ 1,000,000
<b>Central Facilities &amp; Systems</b>							
TSP Traffic System Software	2020	20	1	\$ 75,000	\$ 2,000	\$ 75,000	\$ 2,000
Grant Overhead and Administration (3% of Total)	2017 to 2020	-	1	\$ 1,939,041	-	\$ 1,939,041	
<b>US 29 BRT Service</b>							
Marketing & Startup	2019	-	1	\$ 1,250,000	-	\$ 1,250,000	
Operations	2020	-	1		\$ 5,100,000	\$ -	\$ 5,100,000
Subtotal						\$ 66,573,725	
<b>Other</b>							
Contingency							
<b>Total</b>						<b>\$ 66,573,725</b>	

a Economic Life:  
 ITS from the ITS Joint Program Office Cost Database(5/12/2015): <http://www.itscosts.its.dot.gov/its/benecost.nsf/AdjustedUnitCosts>  
 Transit Structures, Sidewalks, vehicles, from FTA New Starts/Small Starts Evaluation of Alternatives (5/12/2015): [http://www.fta.dot.gov/12304\\_9718.html](http://www.fta.dot.gov/12304_9718.html)

### 4.1 Capital Costs

The life cycle capital costs are shown in the Capital Cost NPV tab and also shown in



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Table 9. As shown each asset is replaced at the end of its economic life. For those that extend beyond the 21 year analysis period a residual capital value is estimated for the remaining years of useful life. Note, that this leads to a higher overall life cycle cost than the initial \$66.57 million. The life cycle capital costs increase to \$195,533,930 in undiscounted 2015\$ (\$65.4 million NPV at 7% discount and \$99.6 million NPV at a 3% discount rate) over the 21 year life of the project. This is primarily due to the replacement of the different components at the end of their economic life (vehicles at 12 years, bicycle stations and bikes at 10 years, passenger information displays at 5 years, and many other assets at 20 years). Note that the assets replaced at 20 years such as the Bus On Shoulder lane improvements are in service for only 1 year, before the end of the analysis. All remaining value for these and other assets that have not reached the end of their economic value is subtracted in the Residual Capital Recovery calculations.

**Table 9 Capital Cost NPV**

Year	Life	Plan, Eng, Design	Vehicles		Concrete Pad	Stops/Stations						Roadside ROW				Central	BRT			Total 2015 \$	Current Year = 2015		
			Vehicles	TSP		Station Upgrades	RTP1 Signs	ROW & Easements	Off Board Fare Equip.	Benches, Trash Cans, Bike Racks & Bike Parking	Bicycle Share Stations	ADA Sidewalk Upgrades	TSP Field Equip	Signing & Marking	Signal Changes	Bus On Shoulder	TSP Software	Grant Admin	Marketing & Startup		RideOn + O&M	NPV 7%	NPV 3%
2015		--	12	10	20	30	5	125	25	30	10	25	10	20	20	20	20	-	-	-	\$ -	\$ -	\$ -
2016																					\$ -	\$ -	\$ -
2017		\$ 2,166,667																			\$ 484,760	\$ 423,408	\$ 456,932
2018		\$ 2,166,667																			\$ 484,760	\$ 395,709	\$ 443,624
Startup		\$ 2,166,667	\$ 13,000,000	\$ 240,000	\$ 720,000	\$ 3,977,984	\$ 362,100	\$ 800,000	\$ 1,704,000	\$ 380,600	\$ 800,000	\$ 1,300,000	\$ 525,000	\$ 5,500,000	\$ 7,500,000	\$ 20,000,000	\$ 75,000	\$ 484,760	\$ 625,000		\$ 57,994,444	\$ 44,243,684	\$ 51,527,313
1	2020																				\$ 484,760	\$ 625,000	\$ 957,289
2	2021																				\$ -	\$ -	\$ -
3	2022																				\$ -	\$ -	\$ -
4	2023																				\$ -	\$ -	\$ -
5	2024																				\$ -	\$ -	\$ -
6	2025						\$ 362,100														\$ 362,100	\$ 184,073	\$ 269,436
7	2026																				\$ -	\$ -	\$ -
8	2027																				\$ -	\$ -	\$ -
9	2028																				\$ -	\$ -	\$ -
10	2029																				\$ -	\$ -	\$ -
11	2030			\$ 240,000			\$ 362,100						\$ 525,000								\$ 1,927,100	\$ 698,470	\$ 1,236,932
12	2031																				\$ -	\$ -	\$ -
13	2032		\$ 13,000,000																		\$ 13,000,000	\$ 4,115,467	\$ 7,865,214
14	2033																				\$ -	\$ -	\$ -
15	2034																				\$ -	\$ -	\$ -
16	2035						\$ 362,100														\$ 362,100	\$ 93,574	\$ 200,486
17	2036																				\$ -	\$ -	\$ -
18	2037																				\$ -	\$ -	\$ -
19	2038																				\$ -	\$ -	\$ -
20	2039																				\$ -	\$ -	\$ -
21	2040			\$ 240,000	\$ 720,000		\$ 362,100				\$ 800,000		\$ 525,000	\$ 5,500,000	\$ 7,500,000	\$ 20,000,000	\$ 75,000				\$ 35,722,100	\$ 6,581,768	\$ 17,061,074
Residual	7%		\$ 4,295,286	\$ 222,629	\$ 702,437	\$ 2,088,597	\$ 299,134	\$ 799,466	\$ 495,282	\$ 199,830	\$ 742,098	\$ 377,856	\$ 487,002	\$ 5,365,839	\$ 7,317,053	\$ 19,512,141	\$ 73,171				\$ 42,977,822	\$ 7,918,628	
Cap Value	3%		\$ 3,694,187	\$ 219,065	\$ 693,205	\$ 1,580,220	\$ 293,897	\$ 782,461	\$ 363,744	\$ 151,190	\$ 730,216	\$ 277,505	\$ 479,204	\$ 5,295,314	\$ 7,220,882	\$ 19,255,686	\$ 72,209				\$ 41,108,983	\$ 9,633,879	
<b>Total</b>																					\$ 195,533,930	\$ 65,446,024	\$ 99,652,180

## 4.2 Operations and Maintenance Costs

The life cycle operations and maintenance costs are provided in the O&M NPV tab and also in Table 10. The operation and maintenance (O&M) costs of \$145,230,733 in undiscounted 2015\$ (\$103.55 million NPV at 7% discount and \$125.28 million NPV at a 3% discount rate) is significant and driven by the additional \$5.1 million annual cost to operate the US 29 BRT service. Other significant annual expenses include the maintenance of way at \$1 million per year, signing and marking at \$275 thousand, stations at \$200 thousand, fare equipment at \$127 thousand and bicycle share stations at \$125 thousand. The additional costs for the service operations are likely to be high since the concomitant savings from the service reductions of parallel service on the Express Z line routes in the corridor were not included, since they are operated by the Washington Metropolitan Area Transit Authority (WMATA) and could not be used to offset Montgomery County costs. While the specific reduction in parallel service has not been calculated at this time, benefits can be realized by assuming reductions in parallel route service of up to 10% per route since the ridership estimation and forecasts predicted a noticeable shift in existing riders to the new US 29 service.

**Table 10 O&M Cost NPV**

	Year	Vehicles		Stops/Stations						Roadside				Central	RideOn +	Total 2015 \$	Current Year = 2015		
		Vehicles <sup>a</sup>	TSP	Bus Pads	Station Upgrades	RTPI Signs	Off Board Fare Equip	Station Amenities	Bicycle Share Stations	TSP Field Equip	Signing & Marking	Signal Changes	Bus On Shoulder	TSP Software	O&M		NPV 7%	NPV 3%	
	2015																		
	2016																		
Startup	2017																		
	2018																		
	2019																		
1	2020	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
2	2021	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
3	2022	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
4	2023	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
5	2024	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
6	2025	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
7	2026	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
8	2027	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
9	2028	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
10	2029	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
11	2030	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
12	2031	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
13	2032	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
14	2033	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
15	2034	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
16	2035	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
17	2036	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
18	2037	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
19	2038	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
20	2039	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
21	2040	\$ 5,000	\$ 36,000	\$ 198,899	\$ 17,000	\$ 127,800	\$ 7,300	\$ 125,000	\$ 18,000	\$ 275,000	\$ 3,750	\$ 1,000,000	\$ 2,000	\$ 5,100,000	\$ 6,915,749	\$ 4,930,834	\$ 5,965,586		
		a Vehicle maintenance included in the Ride On Plus Service O&M														<b>Total</b>	\$145,230,733	\$103,547,506	\$125,277,306

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